Potsdam Institute for Climate Impact Research

Implications of German and European climate targets and policy instruments for the use of coal

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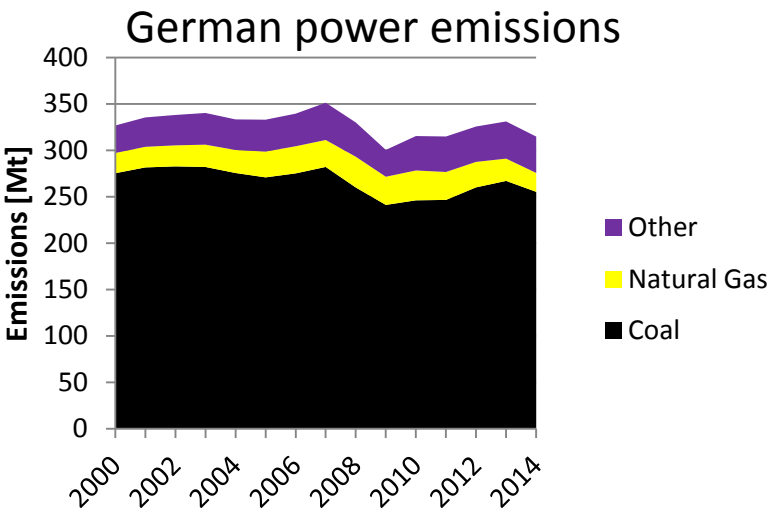
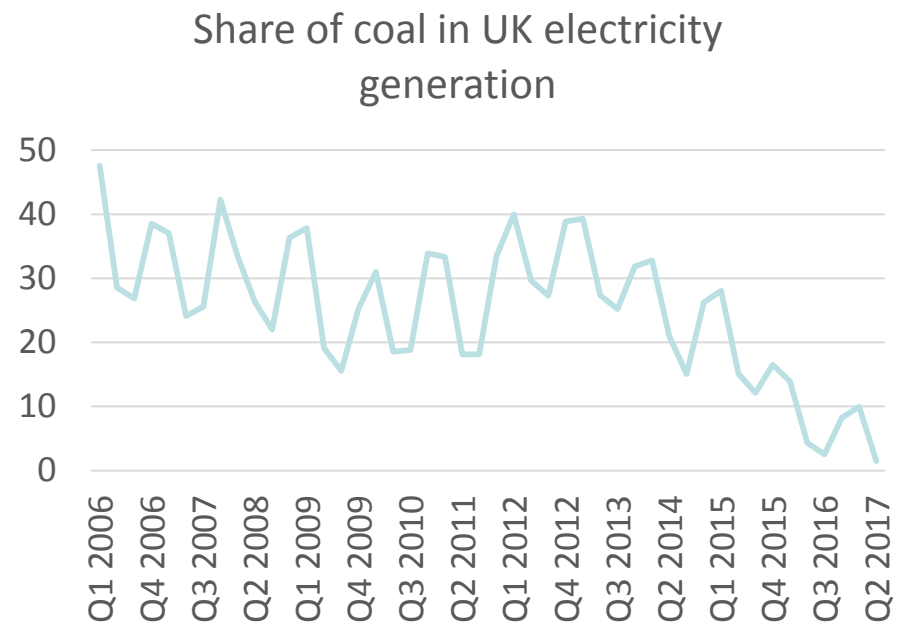
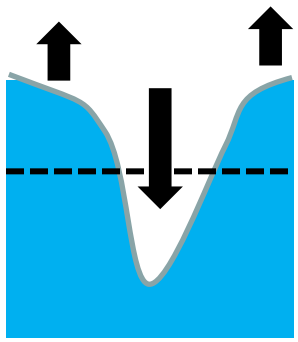
Leibniz Association

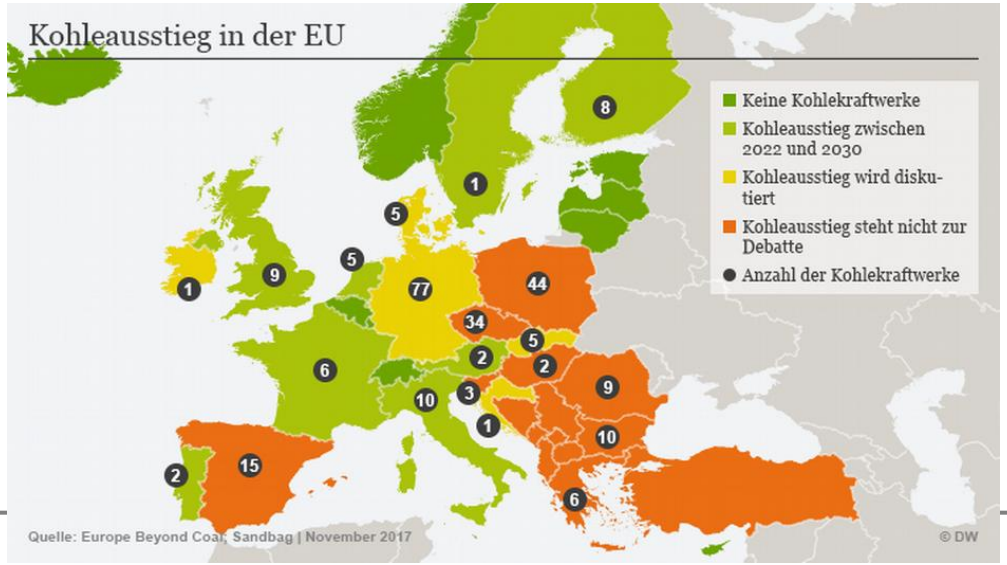
Coal use for power generation







Waterbed effect



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Sources: BMWi; OFGEM; Europe beyond Coal - Sandbag;

ENavi Project

- One of four BMBF KOPERNIKUS-projects on the Energiewende
- ENavi focus: „Systemintegration“ – beyond the technical aspects!
- Many partners:

Partner	Assoziierte Partner
Institute for Advanced Sustainability Studies (IASS)	100 % Erneuerbar Stiftung
Becker Büttner Held	ABB AG
Bergische Universität Wuppertal	Bundesverband Carsharing
Deutsches Zentrum für Luft- und Raumfahrt e. V. (DLF	Cluster Energieforschung NRW
DIALOGIK gemeinnützige Gesellschaft für Kommunika	Deematrix Energiesysteme GmbH
Forschungs-GmbH Wismar	Deutsche Bahn AG
Fraunhofer-Institut für Solare Energiesysteme (ISE)	Deutsche Energie-Agentur GmbH (DENA)
Fraunhofer-Institut für System- und Innovationsforsc	Deutsche Gesellschaft für Sonnenenergie
Fraunhofer-Institut für Windenergie und Energiesyst	Deutsche Umwelthilfe e.V.
GESOBAU AG	EA European Academy of Technology and Innovation Assess
Global Climate Forum	ELDE Energiedörfer/Modellregion Gemeinde Bollewick
Helmholtz-Zentrum für Umweltforschung GmbH (UFZ	Energieagentur NRW
Helmholtz-Zentrum Potsdam Deutsches GeoForschur	Fichtner IT Consulting AG
HOWOGE Wohnungsbau GmbH	Forschungszentrum Jülich
Institut für Klimaschutz, Energie und Mobilität - Recht	Fraunhofer-Einrichtung für Gießerei-, Composite- und Verar
Innovationszentrum für Mobilität und gesellschaftlich	GEODE
Institut für sozial-ökologische Forschung GmbH (ISOE	GEO-EN Energy Technologies GmbH
Internationales Institut für nachhaltiges Energiemana	Industrie- und Handelskammer Potsdam
Karlsruher Institut für Technologie (KIT)	RWE/Innogy Stiftung
Kisters AG	KSB AG
KMGNE - Kolleg für Management und Gestaltung Nach	Landkreis Nordwestmecklenburg
Naturschutzbund Deutschland (NABU) e.V.	Munich RE
Otto-von-Guericke-Universität Magdeburg	MVV Energie AG
Öko-Institut e. V.	Netze Baden-Württemberg GmbH
Potsdam Institut für Klimafolgenforschung (PIK)	Next Kraftwerke GmbH
Reiner Lemoine Institut	Robert Bosch GmbH
Rheinisch-Westfälische Technische Hochschule Aache	Siemens AG
RWI - Leibniz-Institut für Wirtschaftsforschung e. V.	Stadtwerke Grevesmühlen
Simon Process Engineering GmbH	Stadtwerke Heidelberg
Stadtwerke Gotha GmbH	StoREgio Energiespeichersysteme e. V.
Stadtwerke Rosenheim	Technische Universität München
Technische Universität Berlin	Universität Siegen
Technische Universität Darmstadt	Velokonzept Saade GmbH
Universität Bremen	VENTURY GmbH Energieanlagen
Universität Stuttgart	Verbraucherzentrale NRW
Universität Kassel	Verkehrsclub Deutschland
VSE AG Saarbrücken	Verkehrsverbund Rhein-Neckar
Westfälische Wilhelms-Universität Münster	Viessmann Werke
Wuppertal Institut für Klima, Umwelt, Energie gGmbH	
Zentrum für Europäische Wirtschaftsforschung GmbH (ZEW)	
Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW)	
Zeppelin Universität gGmbH	
Zivilgesellschafte Plattform Forschungswende, c/o Vereinigung Deutscher Wissenschaftler (VDW e.V.)	

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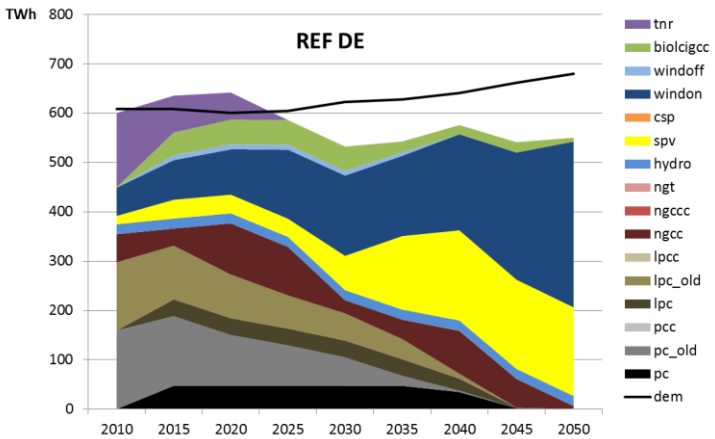
ENavi: strong inter/transdisciplinary approach

Decarbonization Scenarios

Model-based & empirical analysis of **policy designs**



Analysis of **legal & governance aspects**

Stakeholder participation

Assessment of pathways,
policy packages for "navigation"
Considering acceptance and other social issues

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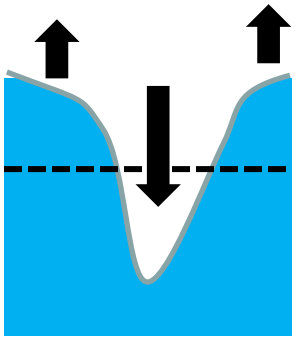
Short-term focus Topic 1: Power sector decarbonization

- How and through which policies can Germany decarbonize its power sector?
- How would German policies interact with EU policies, and how would this interaction affect generation and investment in Germany and neighboring states?



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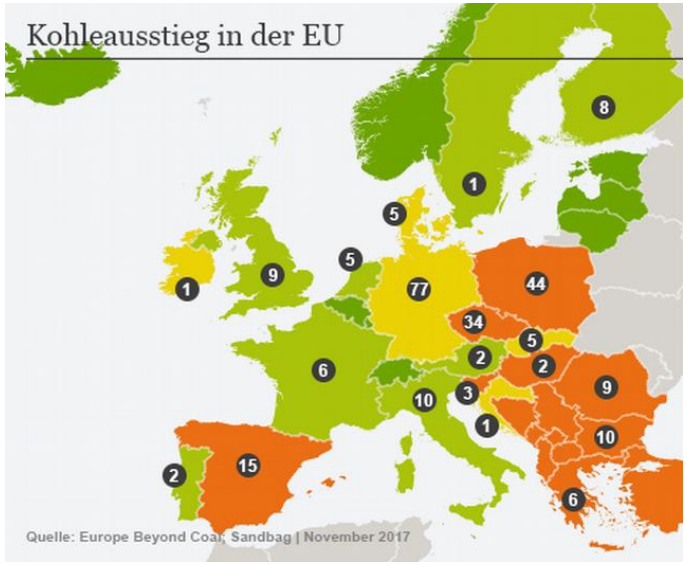
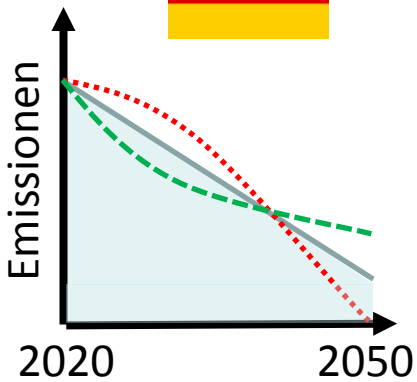


Dimensions of target formulations and policy instruments

1. **European Integration**

2. **Temporal path of emission reductions**
   - **For the climate, mostly the SUM of yearly matters (bspw. 2020-2050)**
   - **Earlier/later emission reductions preferable?**



3. **Sectoral split of emission reductions:**
   - **Political aspect: „Burden“ for respective industries**
   - **Economic analysis: what do reductions in the different sectors cost?**
     => derive efficient contributions from power, transport, …

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Scenario matrix for analysed pathways

Implementation,
legal and Governance questions, …

EU

Germany

	weak EU ambition, e.g. low CO2 prices	**Coalition of Willing:** North-west EU sees 30€/tCO2 in 2020, 120 in 2050	**all EU has ambitions policies**
current policies	●		
Klimaschutzplan (KSP)			●
KSP, but cost-efficient allocation over time and sectors			
Minimum CO2 price of 30€/tCO2	●	●	●
explicit shutdown of plants			

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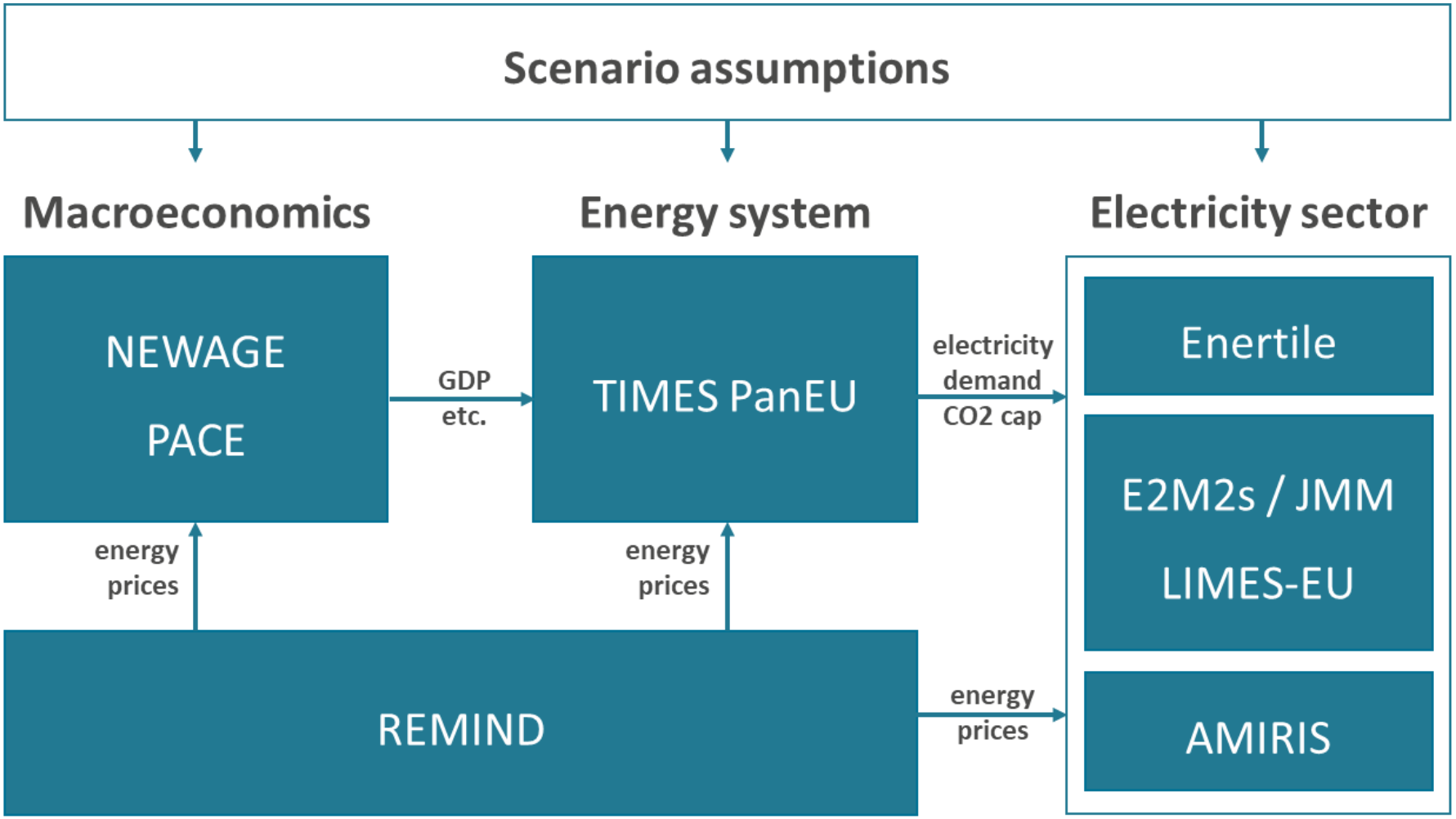
Approach: modelling the different levels



carbon leakage,
competitiveness, effects on
labour markets,
GDP & structure of economies

first best vs. sectoral targets

LIMES-EU *Long-term investment model of the electricity sector*

Objective

- minimizing cumulated costs for electricity provision
- optimal investment and dispatch decisions for generation, storage and transmission capacities

Linear optimization model

- GAMS / CPLEX Solver

Technologies

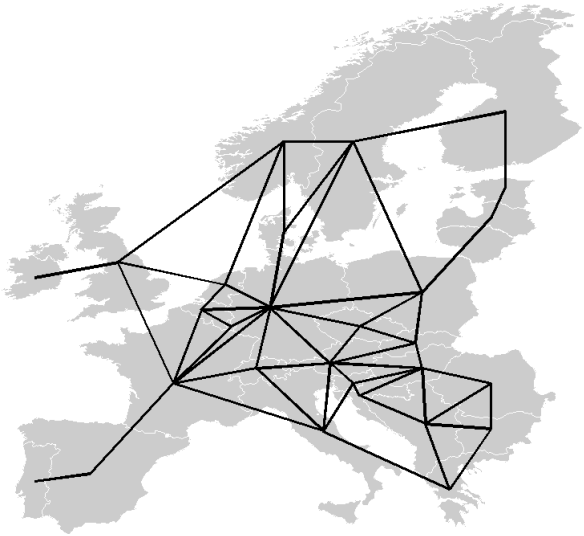
- generation *[wind on-/offshore, solar pv/csp, biomass, hydro, nuclear, hard coal (+ccs), lignite (+ccs), natural gas cc(+ccs)/gt]*
- storage *[diurnal, seasonal]*
- transmission *[net transfer capacities between regions]*

Geographical scope & resolution

- EU28 countries w/o Malta & Cyprus
- plus Norway & Switzerland & Balkan

Temporal scope & resolution

- 5 year steps 2010 – 2050
- 6 representative days per year with 8 time slices of 3h
- perfect foresight



Policy equations

- CO_2 targets / RES targets
- EU or Member State level

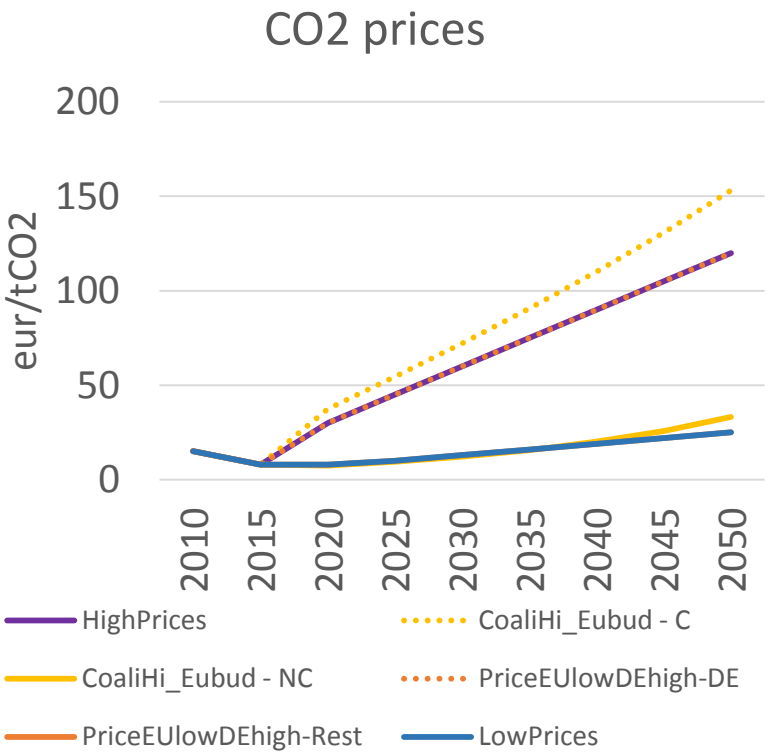
Exogenous parameters

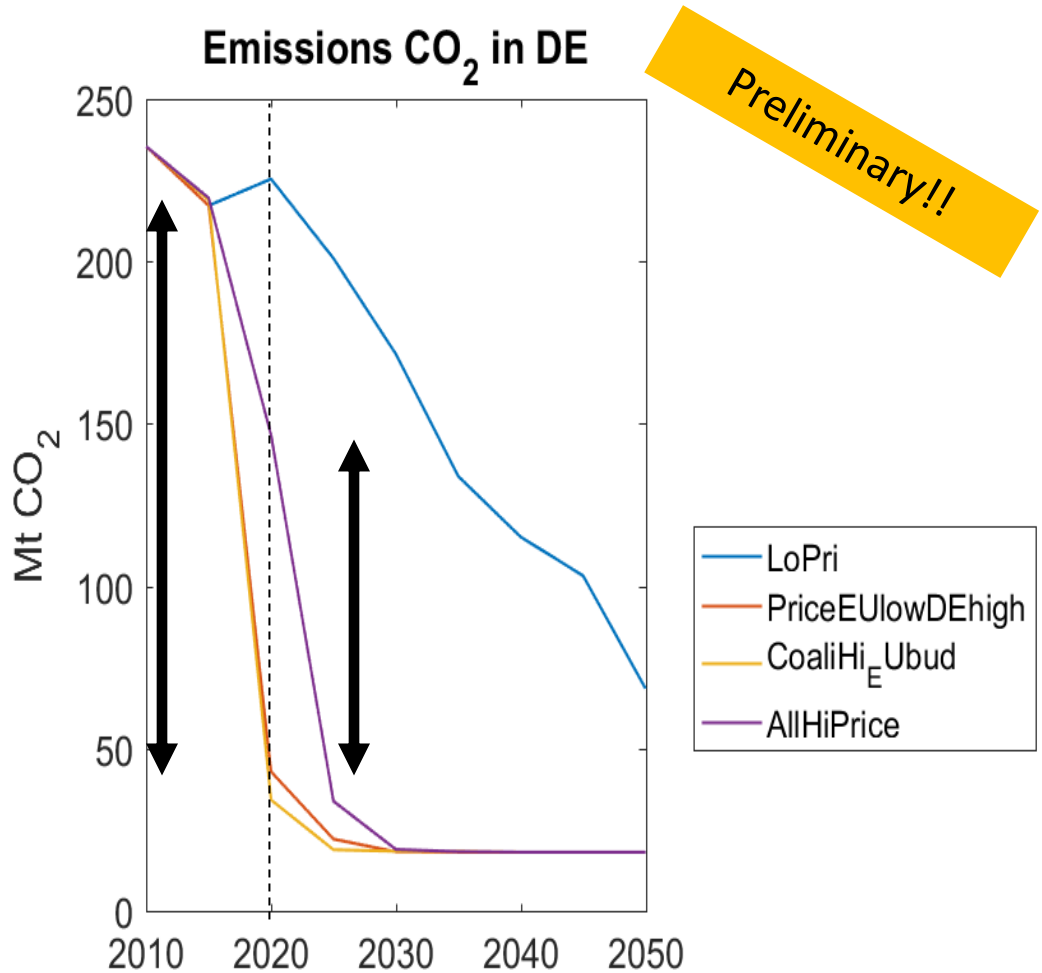
- electricity demand per region
- nuclear / ccs policies
- investment costs
- fuel costs
- …

See Nahmmacher et al. (2014)

(Very) Preliminary Results

30€/tCO2 have strong effect on German emissions

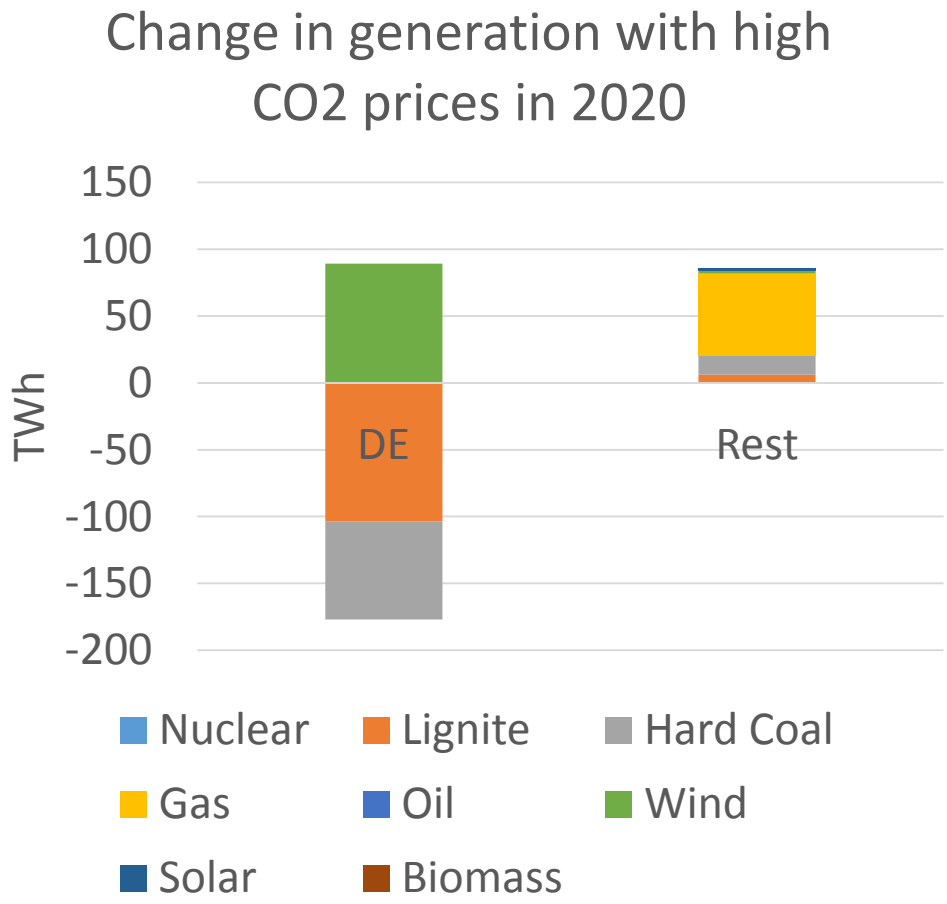


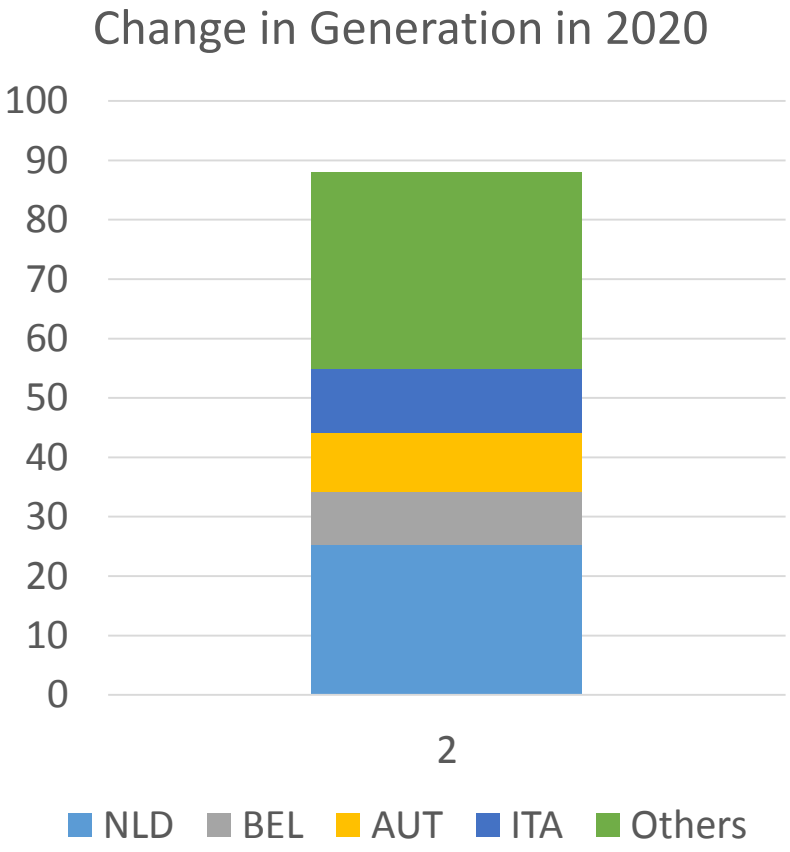


Substantial reductions if only Germany sees increased CO2 price
Effect is halved if all EU sees it

Coal in Germany is replaced by imports

Preliminary!!

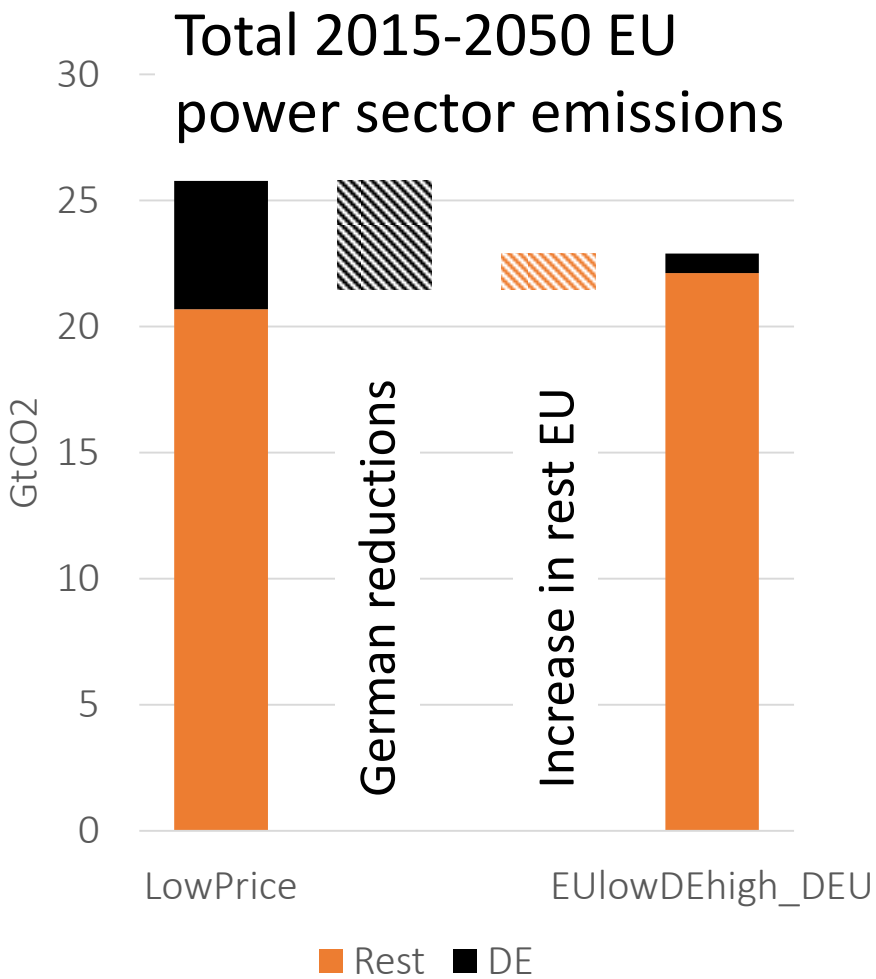




Short-term imports come mostly from gas
A variety of countries increase their generation

Carbon leakage

Preliminary!!

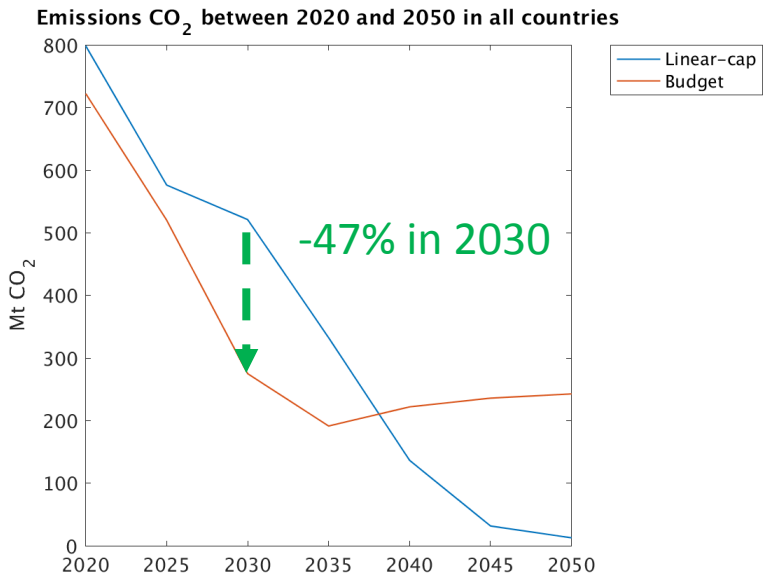


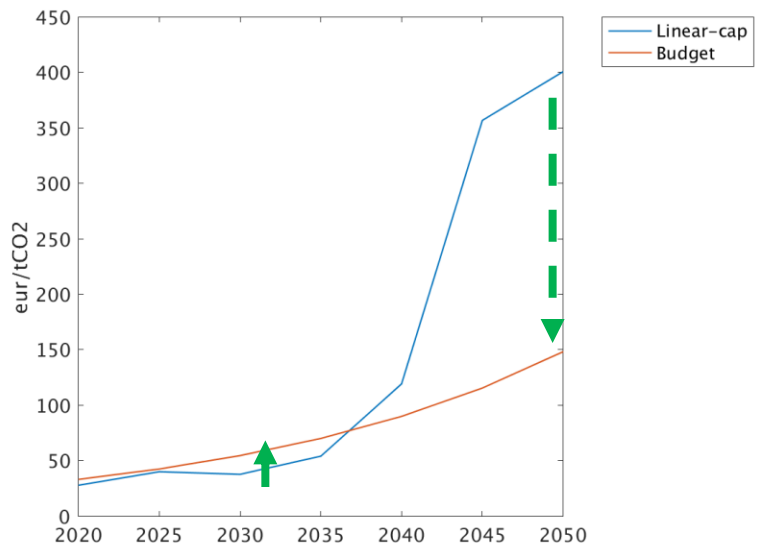
Even if rest of EU sees **fix (but low) carbon prices**, ~30% leakage
Carbon leakage woud likely increase if restEU sees completely flexible ETS

Timing of emission reductions

Preliminary!!

- **Klimaschutzplan and EU targets are based on roughly linear emission reductions**





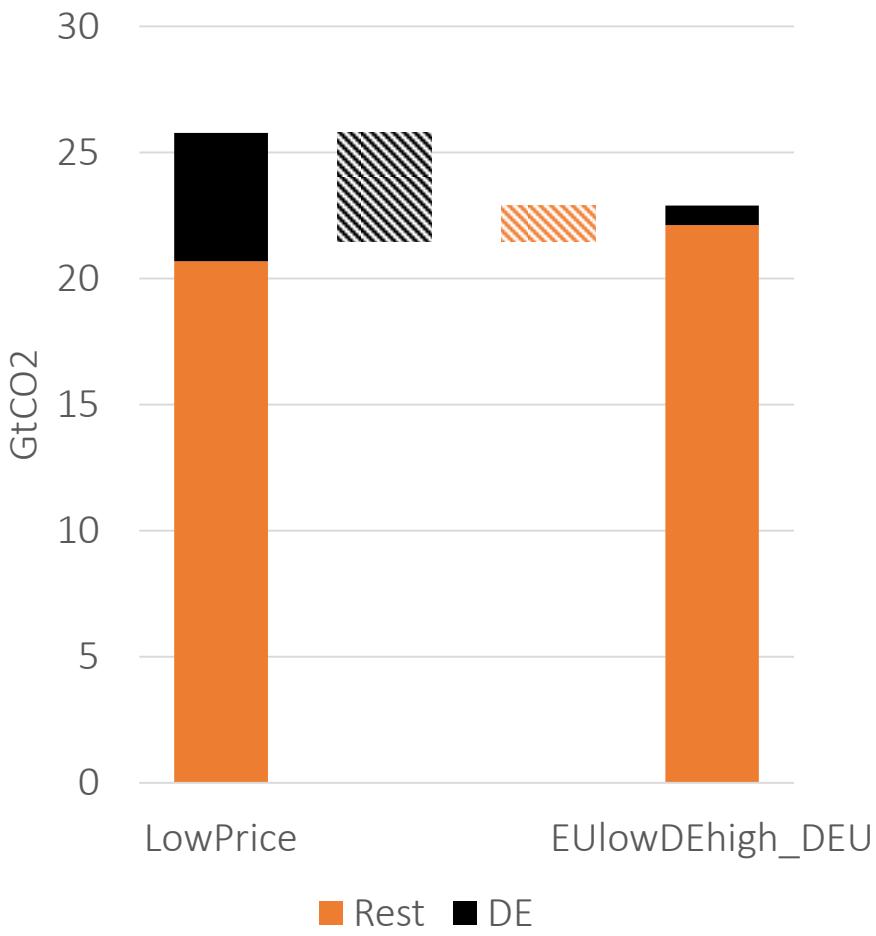
- **Cost-efficient path leads to higher reductions in 2030**
- **This strongly reduces necessary CO2 prices in 2050, and reduces total costs**

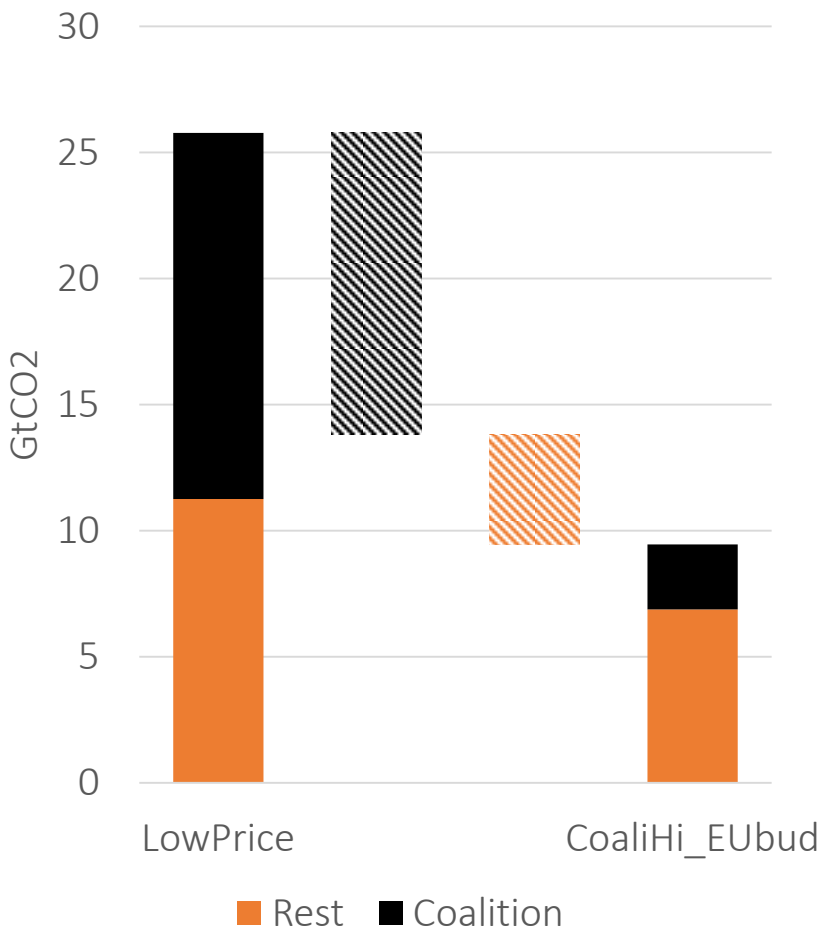
Summary

- Important to analyse the interactions of German and EU policies, both on **techno-economic** and **legal & governance** aspects (not touched upon in this talk)
- Strong short-term reductions of coal generation in Germany will result in substantial imports starting in 2020
- These imports come from various countries, and mostly gas power
- Timing of German and EU targets: ususally linear, which implies inefficient medium-term efforts
  => stronger short-term reductions would be efficient

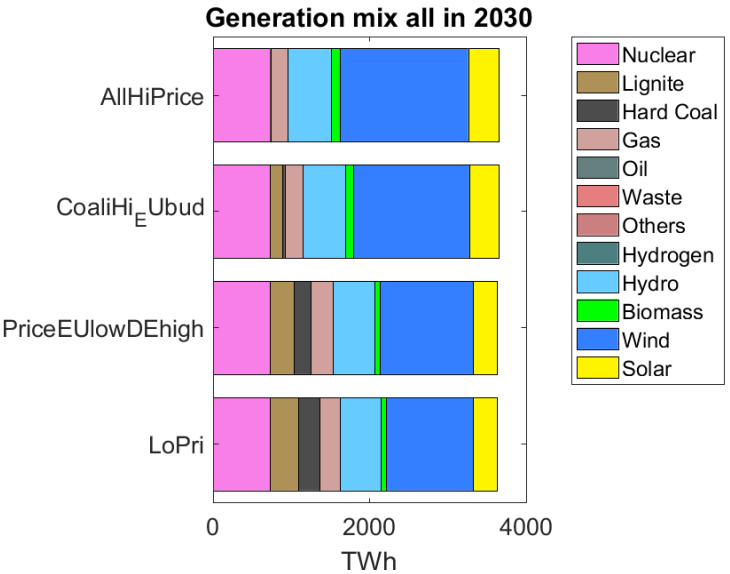
Backup

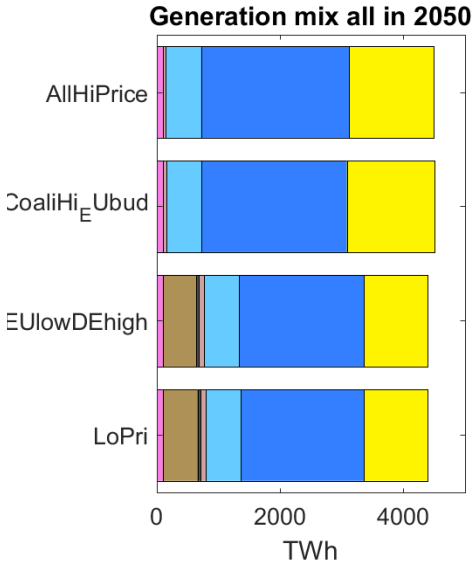
Carbon leakage





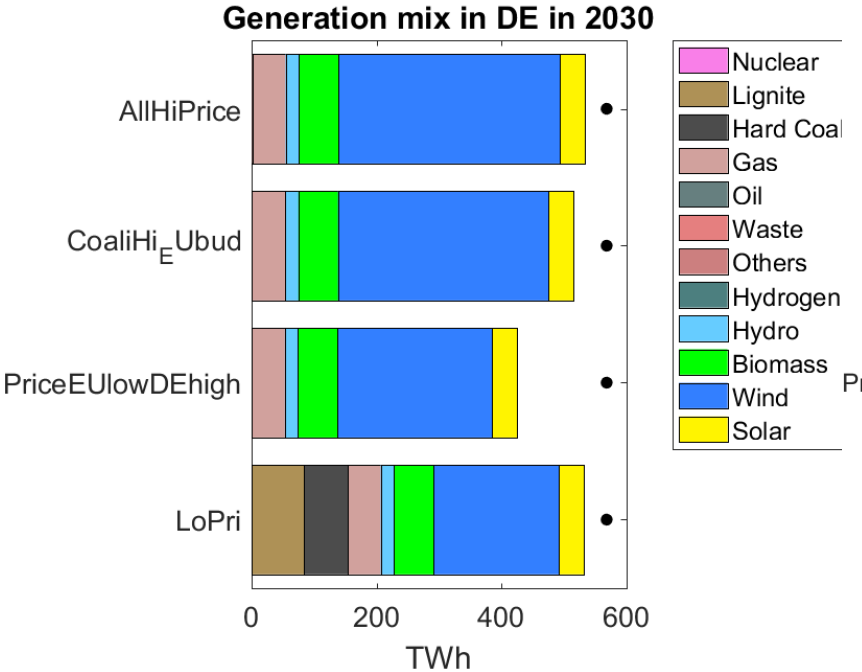
Evolution of the generation mix

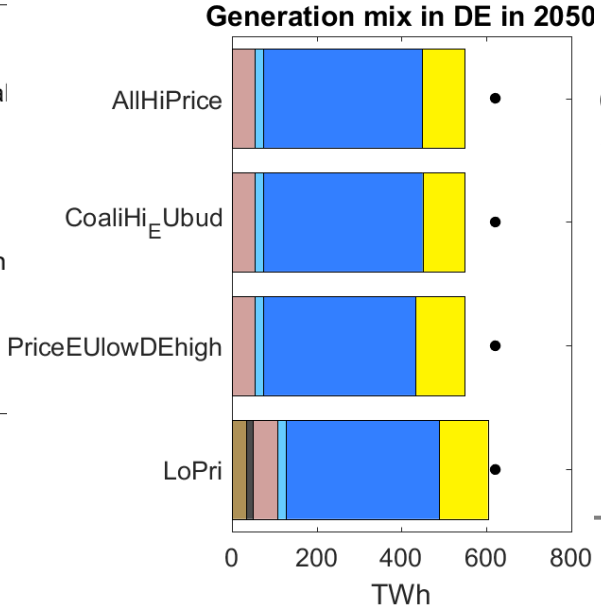




Coal phase-out almost completed in 2030 with high prices

At low prices, still substantial coal use

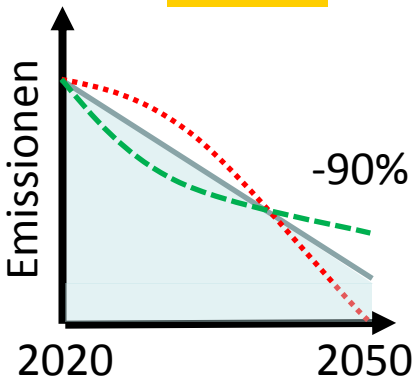




Germany becomes a net importer in all scenarios

Ausgestaltung mit Zielen und Instrumenten: Strukturierende Faktoren

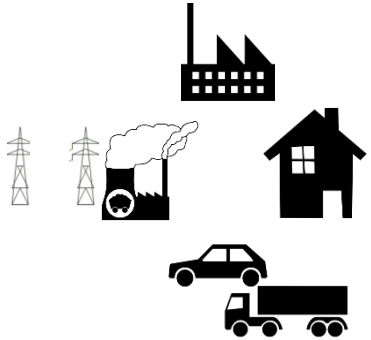
1. **Europäische Interaktion**
   - **Welche Ziele & Instrumente existieren auf europäischer Ebene, welche in Deutschland und anderen MS?**



2. **Zeitliche Verlauf von Emissionsreduktionen**
   - **Für das Klima ist die Summe über jährliche Emissionen relevant (bspw. 2020-2050)**
   - **Frühere/spätere Emissionsreduktion?**

3. **Sektorale Aufteilung der Emissionsreduktionen:**
   - **Ökonomische Betrachtung: was kosten Reduktionen in den verschiedenen Sektoren?**
   - **Politischer Aspekt: „Lasten“ für jeweilige Industrien**

3. Sektorale Aufteilung der Emissionsreduktio



- **Zentrale Frage: Wie viel tragen einzelne Sektoren zu Emissionsreduktionen bei (Sektorziele)?**
- **Erste Erkenntnisse (Szenarien D2/D3/D4): ökonomisch vorteilhaft, Emissionen im Stromsektor stärker zu reduzieren als Klimaschutzplan**

Durch verschiedene Instrumente realisierbar

Tabelle 2: Emissionen der in die Zieldefinition einbezogenen Handlungsfelder

Handlungsfeld	1990 (in Mio. Tonnen CO_2-Äq.)	2014 (in Mio. Tonnen CO_2-Äq.)	2030 (in Mio. Tonnen CO_2-Äq.)	2030 (Minderung in % gegenüber 1990)
Energiewirtschaft	466	358	175 – 183	62 – 61 %
Gebäude	209	119	70 – 72	67 – 66 %
Verkehr	163	160	95 – 98	42 – 40 %
Industrie	283	181	140 – 143	51 – 49 %
Landwirtschaft	88	72	58 – 61	34 – 31 %

Quelle: Klimaschutzplan 2050

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